Research Article

Potassium Application on Chickpea Crop under Irrigated Area

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Abstract | Chickpea is one of the largest and highly cultivable pulse crops which plays a major part in fulfilling the nutritional requirements of human. Limited research has been done on chickpea concern with potassium (K) fertilizer application. A field study was carried out to determine the effect of K on chickpea using cultivar Benazir having three fertilizer treatments; 0:0:0, 30:75:0 and 30:75:30 kg ha^{-1} of N:P:K replicated thrice with randomized complete block design respectively. The experimental soil was clay loam in texture. Application of N, P and K showed significant effect on chickpea growth and yield parameters. The maximum plant height (85.00 cm), pods plant^{-1} (43.8), seed index (455 g per 1000 grains), seed yield (1896.0 kg ha^{-1}), total biomass (5205 kg ha^{-1}), straw yield (31050 kg ha^{-1}), protein (15.77%), shoot N, P and K (2.1, 0.3 and 1.3 %) concencentration and N, P and K uptake (95.3, 16.4 and 49.9 kg ha^{-1}) were recorded by combined application of N, P and K fertilizer application. However, the minimum values were obtained from control treatment. The combined application significantly increased chickpea yield compared the one without K application. There was positive significant relationship between all yield parameters except straw yield. Hence, it was recommended that combined application of N, P and K fertilizers is essential for the growth and yield enhancement of chickpea.

Received | March 02, 2018; **Accepted** | November 01, 2018; **Published** | November 26, 2018
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Citation | Rajput, A. 2018. Potassium Application on Chickpea Crop under Irrigated Area. *Sarhad Journal of Agriculture,* 34(4): 941-947.
DOI | http://dx.doi.org/10.17582/journal.sja/2018/34.4.941.947
Keywords | Levels, Growth, Treatments, Yield parameters

Introduction

Pulses are important leguminous food crops in the world, and play a significant role in Pakistan agriculture. It provides 2 to 3 times more protein than the other cereals (Shabir, 2009; Sial et al., 2012: Shukla et al., 2013) and contribute 20% of the world human food. Chickpea (*Cicer arietinum* L.) is winter season leguminious crop (Soltani et al., 2006). It is grown all tropics arid, semiarid, temperate zone and rain-fed areas of the world. It serves as a food in human diet and has ability to fix atmospheric nitrogen to improve soil fertility (Siddiqi and Mahmood, 2001; Kantar et al., 2007). It is grown for its nutritional value with high nutrient content as dietary P (340 mg 100 g^{-1}), Ca+Mg (140 mg 100 g^{-1}), Fe (7 mg 100 g^{-1}) and Zn (3 mg 100 g^{-1}). It also contains protein (23%), carbohydrates (64%), fat (5%), crude fiber (6%) and having considerable amounts of vitamin A, B and C. (Deppe, 2010). Pulses are grown in Pakistan at about 931 thousand hectares, producing 359,000 tons with grain yield of 386 kg ha^{-1} GoP (2017). However, in Sindh province, it was cultivated on an area of about 22 thousand hectares with total production 19000 tons with grain yield of 864 kg ha^{-1} GoP (2017). The average chickpea yield (386 kg ha^{-1}) of Pakistan is comparatively lower than other countries such as China (3300 kg ha^{-1}), Canada (1900 kg ha^{-1}), USA (1700 kg ha^{-1}), Lebanon (2300 kg ha^{-1}) and Egypt (1700 kg ha^{-1}) (FAO, 2009; Anon, 2010). Potassium is a major macro element taken up from the soil in large quantity used as a catalyst, chlorophyll formation, respirations, photo-

synthesis, water regulation and synergistic effect with nitrogen and phosphorus (Sahai, 2004). However, research on K application has not received on pulses crop in Sindh, Pakistan (Singh et al., 2007). Potassium (K) fertilizer is a very costly agricultural input in Pakistan and farmers are not being using for crop production (Nawaz et al., 2006). In contrast, in chickpea the application of K is negligible(Asif et al., 2007; Srinivasarao et al., 2003; Memon et al., 2016), whereas its application has beneficial effects on crop yield (Verma and Pandya, 2003; Saeed et al., 2004; Boulbaba et al., 2005; Ganga et al., 2014). Furthermores, K fertilizer application in chickpea crop generally neglected by farming community due to its high prices.

Many researchers related effect of fertilizer doses and their combined applications on response of chickpea crop (Saeed et al., 2004; Ali et al., 2010; Rashid et al., 2013; Badini et al., 2015; Memon et al., 2016). In addition, the combined application of K with other elements showed positive impacts on the crop production. The various levels of K with sulphur resulted maximum dry matter accumulation, number of pods plant^{-1}, 100 seed weight, seed yield, protein content and N, P and K uptake. The various K application influenced the growth and yield paprameters of chiclpea, the low rate enhanced the nodular, shoot and root biomass, whereas, the maximum yield was achieved at higher dose of K (Boulbaba et al., 2005). Furthermore, the combined various rates of P_2O_5 and K on the yield of chickpea cultivar (CM-98) produced highest plant height, pods bearing branches plant^{-1}, pods plant^{-1}, seed pods^{-1}, seed plant^{-1}, grain yield, biological yield, straw yield and 1000 grain weight (Asif et al., 2007; Ganga et al., 2014; Kumar et al., 2014). Keeping in this view the importance of K for chickpea crop growth enhancement, the present study was planned to carry out fertilizers (NPK) applications with and with out K application for the higher growth and yield of chickpea (Benazir cultivar) under irrigated soil conditions.

Materials and Methods

Site description

The experimental site was situated at Pulses Research Sub-Station Tandojam, Southern part of Sindh, Pakistan located at 25°25'60N 68°31'60E. The experimental site had a dry climatic weather consisted annual temperature form 27.7 to 35°C and annual rainfall was 150 to 200 mm. The experiment was conducted during the winter season (from November, 2015 to Febrauary, 2016). The experimental soil was alkaline in nature (pH 7.9), non saline (EC 0.36 dSm^{-1}) low in organic matter (0.67%), low in total N 0.03%, marginal in available P (7.38 mg kg^{-1}) and available K (75 mg kg^{-1}) having clay loam (sand 25, silt 35 and clay 45 %) soil texture according to USDA system.

Field layout

Field study was conducted in winter season using by chickpea cultivar (Benazir). The experiment was comprised three fertilizer treatments T1=0:0:0 (Control), T2= NP (30:75:0) and T3= NPK (30:75:30) including with Randomized Complete Block Design (RCBD) using four replications. Chickpea cultivar (Benazir) was sown with seed rate 80 kg ha^{-1} with plot size 2×3.5 m^2, row to row distance was 30 cm and plant to plant distance was kept 15cm by thinning manually. The N was applied in the form of urea (46%N), P (P_2O_5) by single super phosphate (16% SSP) and K in the form of sulphate of potash (60% K_2SO_4). All P, K and N (1/3) were given during land preparation, whereas remaining N was applied at 1st and 2nd time of irrigation after sowing respectively. Field was ploughed with disc harrow and seeds of chickpea cultivar were sown by single coulter hand drill. Thinning was done after 15 days of sowing to maintain a plant to plant distance of 15 cm. Hoeing was done thrice to keep the crop weed free and total three irrigations were given to the crop till harvesting. After 120 days, crop was matured and harvested. Growth parameters such as plant height, number of pods plant^{-1} and 1000 grain weight was determined. Grain yield was observed using by formula = grain yield (kg plot^{-1})/plot size (m^{-2}) × 10000 however, straw yield was determined by subtracting the grain yield from the above ground biomass production.

Environmental conditions during the study

The environmental conditions were varied during the field experimental period. There was no rain precipiatation occurred during the period (Table 1). Howver, the minimum (8.3 °C) and maximum (30.3 °C) temperature was fluctuate, but the relative humidity was remained 44-59 % during the experimental period. The sunshine was remained between 8.0-9.1 hrs and wind speed was remained same 2.3 – 3.0 km/hr and evaporation was varied (3.1 - 6.2 mm/day) during the period.

Plant shoots sampling and analysis

The plant shoot samples were taken at the time of

Table 1: *Environmental conditions during the study.*

Dates	Total Rain	Temperatures		Relative Humidity	Cloudiness	Sunshine Hours	Wind		Evap:
	m.m	Min:°C	Max:°C	%	Octas	Hrs	Speed Km/hr	Directions	mm/day
Nov 15	0.0	14.5	30.3	48	0.1	8.6	3.0	N	4.4
Dec 15	0.0	8.3	25.8	58	1.0	8.6	2.3	N	3.1
Jan 16	0.0	10.3	25.4	59	0.8	8.0	2.7	N	6.2
Feb 16	0.0	9.2	28.4	44	0.4	9.1	2.8	NE	3.4

beginning of flowering stage as given in Grain Legume Hand Book (1998). Each sample was washed with distilled water, dried in an oven at 70°C, and ground to fine size for analysis. The total nitrogen of shoot was determined by micro Kjheldahl's method (Jackson, 1958) and the total P and K was determined (Soltanpour and Schwab, 1977). However, the nutrients uptake was used for calculating N, P and K uptake using following formulae: N- uptake (kg ha^{-1}) = yield (kg ha^{-1}) × plant N (%)/100, P-uptake (kg ha^{-1}) = yield (kg ha^{-1}) × plant P (%)/100 and K-uptake (kg ha^{-1}) = Yield (kg ha^{-1}) × plant K (%) plant K (%)/100. While protein content was determined by multiplying nitrogen percentage with 6.25 (Hiller et al., 1948).

Statistical analysis

The tabulated data were analyzed by statistix 8.1 and means were compared by using least significant difference test ($LSD_{0.05}$) (Steel et al., 1997).

Results and Discussion

Potassium application significantly ($p<0.01$) affected the growth (plant height and number of pods) as well as yield and yield contributing parameters (1000 grain weight, biomass yield and straw yield ($p< 0.05$)). It also had a significant ($p< 0.01$) effect on shoot N ($p< 0.05$), P and K content and the relevant uptakes (Table 2).

Growth parameters

The effect of K application was prominent in chickpea plants showing maximum plant height and maximum number of pods (Figure 1). Plant height increased from 62.2 cm in control to 85.0 cm in treatments applied with NPK (30:75:30 kg ha^{-1}). Generally there was 7% increase in plant height with addition of K over control K treatment (Figure 1a). The lowest number of pods in control (21.7) and highest under NPK treatment (43.8). Number of pods were increased by 100% over control and 13% over without K applications (Figure 1b).

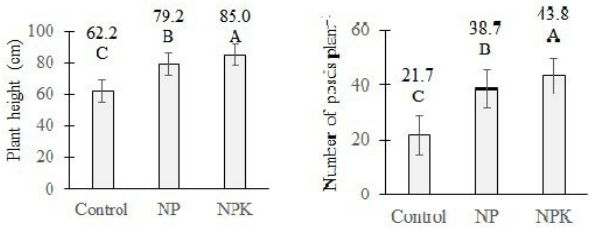

Figure 1: *Effect of K fertilizer application on plant height (a) and number of pods (b).*

Table 2: *Analysis of variance for different different parameters of chickpea cultivar Benazir as affected by K application.*

Parameters	F value	$LSD_{0.05}$	S. E
Plant height (cm)	78.21**	4.64	1.90
Number of pods $plant^{-1}$	198.78**	2.84	1.16
1000 grain weight	32.13**	2.47	1.01
Biomass yield	320.00**	118.20	48.30
Straw yield	5.53*	251.52	102.79
Grain yield	44.91**	241.90	98.85
N shoot content	7.99*	0.55	0.23
P shoot content	29.62**	0.04	0.01
K shoot content	1405.14**	0.06	0.02
N uptake	70.68**	10.76	4.39
P uptake	358.31**	0.73	0.30
K uptake	558.38**	2.20	0.90

NS: *non significant; * and ** significant at 0.05 and 0.01 probability level according to least significant difference (LSD) test.*

Yield and yield contributing parameters

The plants produced 22% more grain weight (1000 grains), 23% biomass yield and 16% straw yield in treatments supplied with K, over those having no K application. The 1000 grain weight, biomass yield and straw yield increased from 375g, 4060 kg ha^{-1} and 3085 kg ha^{-1} to 455g, 5205 kg ha^{-1} and 3309 kg ha^{-1}, respectively over control (Figure 2a, 2c). Grain yield increased from 975 to 1896 kg ha^{-1} over control (Figure 2d). Considering the K application, there was 30% increase in grain yield over no K treatment. Protein content increased from 8.75% in control to

15.77% under NPK treatment. There was 10.4% increase in protein content with the addition of K over NP treatment (Figure 2e).

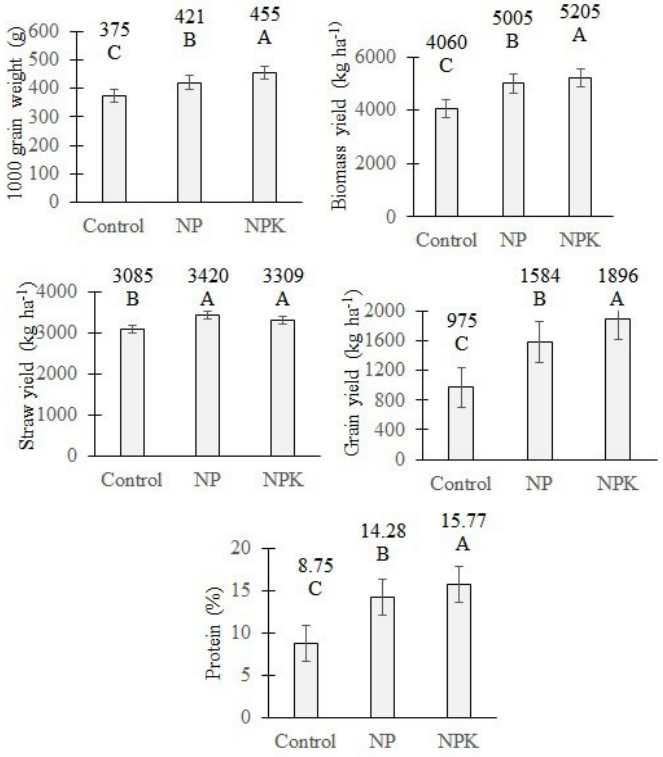

Figure 2: *Effect of K fertilizer application on 1000 grain weight (a), Biomass yield (b), straw yield (c) and grain yield (d) of chickpea stain Benazir and (e) Protein content.*

Nutrient content and uptake

Total N content increased from 1.2% under control to 2.1% in NPK treatment (Figure 3a). While it increased by 16.7% with K application over no K treatment. Total P content increased only slightly and ranged between 0.2-0.3% under NPK over control treatment (Figure 3b). Further, there was no difference in shoot P content of the two treatments (i.e. NP and NPK). Total K content increased from 0.3% in control to 1.3% in NPK treatment (Figure 3c). Considering the relevant uptakes (Figure 3d, 3f), there was 16% increase in N, 13% in P and 29% in K uptake of chickpea plant in treatments supplied with K over those having no K (NP treatment).

Relationship of grain yield with various plant characteristics

Results of correlation analysis showed that all parameters had high positive effects on grain yield whereas, high negative effects belonged to seed index (Table 3).

Plant nutrition play an important role in the growth of many crops. The present study highlighted positive effect on growth and yield of chickpea (Benazir cultivar) by applied K with N and P. The application of K directly influenced the chickpea growth and yield, however, omitting K with N and P decreased yield up to (16.4%). The K is, third major nutrient element after N and P, and play an important role for crop development (Mahjan and Sharma, 2005; Shukla et al., 2010). However, local research related to fertilization on growth and development of chickpea crop is scarce and there were less work on K on chickpea cultivar has been done so far. The different P levels with K application significantly increased plant height (102.4cm), average yield (1058 kg ha^{-1}), shoot P (0.49%), P uptake (5.18 kg ha^{-1}) and protein content (17.4%) over control plot at the rate of 75 P_20_5 kg ha^{-1} at Chickpea (Benazir) cultivar (Memon et al., 2016). Similarly, Asif et al. (2007) conducted experiment on various K rates application on chickpea recorded higher plant height, pods $plant^{-1}$ (97.5) and grain yield CM 98. Goud et al. (2014) the significantly higher yield of chickpea was recorded with the application rate of 40 kg K_2O ha^{-1} closely followed by 30 kg K_2O with continuous three years study. The K application influenced the at the application of 60 kg K_2O ha^{-1} showed maximum plant height (58.8 cm), seeds pod^{-1} (1-4), 100 seed weight (27.5 g) and yield grain (11.84 q ha^{-1}) of the chickpea (Ganga et al., 2014). Our results were also very closely in line with widely held research works (Mondal et al., 2005; Boulbaba et al., 2005; Nabila et al., 2013: Ganga et al., 2014) where various K levels between 25 to 60 K_2O kg ha^{-1}) were effective in enhancing growth and grain yield of different chickpea cultivars and genotypes.

Table 3: *Relationship of chickpea cultivar (Benazir) with some growth, yield shoot and uptake parameters.*

Parameters	Value
Plant height (cm)	0.942**
Number of pods $plant^{-1}$	0.933**
1000 grain weight	0.847**
Biomass yield	0.935**
Straw yield	0.348NS
Protein %	0.883**
N shoot content	0.7163**
P shoot content	0.864**
K shoot content	0.720*
N uptake	0.977**
P uptake	0.952**
K uptake	0.948**

NS: *non significant; * and ** significant at 0.05 and 0.01 probability level according to least significant difference (LSD) test.*

Links Researchers

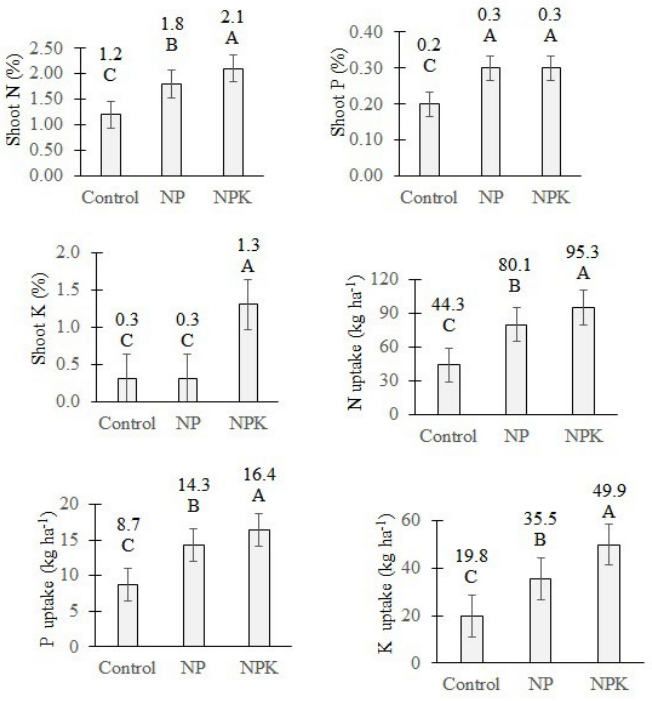

Figure 3: *Effect of K fertilizer application on shoot N (a), shoot P (b), shoot K (c), N uptake (d), P uptake (e) K uptake (f) of chickpea stain Benazir.*

The nutrient uptake was varied among the varies fertilizer treatments. The combined fertilizer (NPK) application significantly showed maximum nutrient uptake in plant shoot of chickpea. The macronutrient (NPK) concentration in chickpea plant shoot showed higher N (3.6 ppm), P (2.56 ppm) and K (0.68 ppm) compared with non-applied K applications (Rehman et al., 2005). Application of NPK appreciably influenced the shoot N, P and K contents, and showed maximum values of reproductive parameters such as seed index (241.5 g): biological, straw and economical yield (Shil et al., 2007). Furthermore, in other leguminous crops (Gram) various NPK levels also their performance on the growth and yield during winter season of 2007-2008. The results further revealed that the maximum plant height (104.7 cm), number of seeds pod^{-1} (1.76) and 1000 grain weight (280.08) was recorded in gram cultivar Paidar 91 than other cultivars applied NPK treatments (Rashid et al., 2013; Ganga et al., 2014).

The nutrients have synergistic effect and combined and balanced use of them perform better way on the plant growth and yields. The use of NPK could help to support plant in a better way for enhancing plant growth parameters which may lead to support in higher crop production. The N, P and K uptake showed positive response with K including N and K application in chickpea cultiver. Combined use of NPK showed significantly positive in chickpea cultivar. These results were supported by Mondal et al. (2005) and Goud et al. (2014) where K levels were 25 and 30 K_2O kg ha^{-1} applied with NP responded positively on the various leguminous crops.

The protein content was varied in all applied fertilizer treatments. It shows that protein content remain higher in combined N, P and K applications. The protein contents also perform major functions in the plant hrowth and plant stress conditions. Mostly, it is corrected with N concentrations in the plants. The protein contents were mostly affected with the various fertilizer applications and it could be remained in the range with the various N, P and K fertilizer application among the different leguminous cultivars (Uddin et al., 2014; Goud et al., 2014). Furthermore, protein contents generally showed tolerance in many plants while addition of mineral fertilizer application with higher rates (Rashid et al., 2013; Memon et al., 2016). During the study, it was found that there was positive significant correlation with growth and yield parameters, however negative correlation was found in grain yield with seed index. The pods number and seed size have the highest direct effect on yield of chickpea, the relationships among the parameters which affected with other parameters and showed significantly positive relation with grain yield (Noor et al., 2003). In addition, the harvest index and biological yield had maximum direct effect on grain yield and positive significant relationships were between seed yield, pods per plant and 100 seed weight (Bhavani et al., 2008).

Conclusions and Recommendations

In this study, it was concluded that application of K with other major nutrients (N and P) influenced the growth and yield enhancement of chickpea (Benazir cultivar). Similarly, K also increased nutrient uptake, protein contents and enhancing other plant growth parameters of chickpea cultivar. Generally, K application performed better in all the growth parameters compared to N and P, and over control treatments. Hence, it is depicted that the recommendation of K with other major nutrients has significantly importance for chickpea crop for better growth and yield parameters.

Acknowledgements

This is original research work and thanks for Department of Pulses Research Sub-station Tandojam which provide land, seed, fertilizer and labour for completion of this work.

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